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(54) Miniature rare gas discharge lamp electrode and method of making.

(57) A method of making a miniature neon lamp electrode (10) having lead (12), can (20), and an emitter coating (40) is disclosed. A needle (44) with a quantity of emitter material (13) is advanced into a sleeve (20). The needle is then spun at high speed to deposit the emitter material (13) on the inside wall of the sleeve (20). The sleeve (20) is then coaxially crimped to a lead (12), forming a narrow entrance hollow cathode having an even and specifically positioned emitter coating (40). The method of making a miniature neon lamp electrode (10) yields a miniature neon lamp electrode (10) capable of withstanding a long life, with many starts, while producing an accurately position arc.

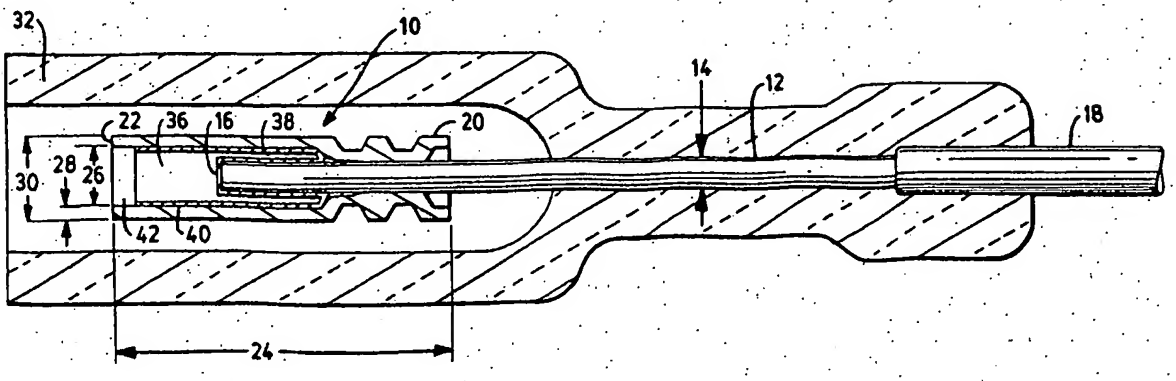

FIG. 1

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1. Technical Field

The invention relates to electric lamps and particularly to discharge lamps. More particularly the invention is concerned with a miniature electrode for a neon or other rare gas discharge lamp.

2. Background Art

Rare gas discharge lamp electrodes are commonly made by first dipping a wire, or coil in a slurry of emissive material and a carrier medium or solvent. The emissive material is then bake to drive off the carrier fluid. The lamp discharge then emanates from the baked on emissive material. As the wire and emissive material heat up, material may sputter from the electrode, and thereafter deposit on the lamp walls. Sputtered material darkens the lamp, and ultimately reduces the emissivity of the electrode. To contain the sputtering, it is not uncommon to enclose the emissive electrode in a can. Sputtered material is then partially trapped in the can where it tends to redeposit on the can wall.

For larger electrodes, the emissive material may be sprayed in the can. Dipping coats both the interior and the exterior of the can, and the exterior emissive material draws the discharge to that exterior region. Discharge from the can exterior is closer to the envelope wall, which then heats the envelope wall, and the can irregularly, detrimentally affecting lamp life. Dipping also encourages large aggregations of material to cling irregularly to the electrode. These irregularities result in hot or cold spots on the electrode that then distort the arc position, and over heat the electrode or the envelope wall.

Spraying does not work well with small volumes. Small crevices resist coating, or alternatively accumulate excessive deposits. Spraying also tends to cover everything inside the can without discrimination. It has been found that not all of the inside of the can should be covered, so there is a need for a method of coating only specific regions inside the can. Also, if the can is small, less than a centimeter, spraying becomes difficult. When the can is less than a few millimeters in diameter, spraying becomes even more difficult. The spray will not reach all parts of the can evenly, leaving some regions under coated and others overly coated.

For a lamp to provide rapid light output, the electrode should have a minimal mass to heat quickly. Dipping, and spray coating may over coat the electrode, leaving a heavy coating of emissive material whose mass takes longer to heat to a full on condition. Conversely, for longevity, the electrode should be massive, and well coated to continue working despite erosion of the materials. Balancing response with long life requires care. There is then a need for a coating method that evenly, but minimally coats the inside of an electrode can. For lamps produced in great quantity, cost and time of manufacture are important. There is then an additional need to create an inexpensive electrode that has fast response, and long life.

Chemical vapor deposition may be used to coat an electrode, but has similar disadvantages. The coating may be even, but there is no selectivity in where the coating is applied. The vapor tends to coat some regions more easily than others, resulting in irregularities. There is then a need for a method of evenly coating the interior of a miniature electrode can.

Neon lamps are known to produce red light, and therefore offer the opportunity of an unfiltered vehicle stop lamp. Typical neon sign lamps are long tubes about one or two centimeters in diameter, that contains the diffused gaseous neon plasma light source. These lamps typically have inputs of from 1100 to 1200 volts, at a few milliamps of power. These lamps give off a diffuse, low intensity light that has a chromaticity that does not meet automotive standards. The warning light from a stop lamp is not required to meet a strict illumination pattern like headlamps are, but there are still point specifications to be met, so the red light may be well seen at great distance. The light must therefore be reflected and focused to concentrated it down the road for proper visibility. A light source with a one or two centimeter diameter cannot be efficiently reflected or focused. There is then a need for a small diameter neon stop lamp.

The SAE has found that a single bright point is not as easily seen as a broader light source. The SAE therefore requires a spread source. In the typical taillamp, using a tungsten filamented lamp behind a red filter, the viewer commonly sees a hot spot where the white lamp overpowers the red filter. Away from the hot spot, the light appears less white or yellow, and becomes redder, but at the same time becomes less intense. The typical vehicle stop lamp then varies across its face in color and illumination intensity. These variations are felt to be unesthetic by vehicle designers. There is then a need for a vehicle stop lamp with an even distribution of color and illumination intensity.

Neon sign lamps have large electrodes at each end that provide great durability. The large electrodes also amounts to a large darkened length at each end of the lamp tube. The darkened lamp ends frustrate vehicle designers trying to provide an even lighting across the lamp face. Vehicles need compact reflectors and lenses for reduced wind resistance, reduced vehicle cost, and enhanced styling flexibility. There is then a need for a small diameter neon lamp that produces a large

number of lumens, without forming an elongated dark spot at each end.

Narrow tube neon lamps do exist. These lamps may have tube diameters of several millimeters, and have small electrodes providing very low output wattages. These lamps are used in artistic signs to be viewed at only a few feet. The small diameter tubes do not produce enough light to be sufficiently visible for vehicle use. Alternatively, a narrow central tube can be connected to a broad end section enclosing the usual heavy electrode. The larger electrode provides increased power, without undue electrode erosion, but again has the large dark spot along the large electrodes at each end.

Some vehicle stop lamps are expected to provide from 100,000 to 800,000 lamp starts within an operating life span of 2000 hours. Common neon lamps can provide such service, but only by making the electrode large, resulting in a diffused light source, and a large dark spot. Making conventional electrodes small has resulted in lamps that sputter the electrode, resulting in a short lamp life, and also coating the lamp interior, thereby darkening the lamp and changing the lamp color. In either case the result for vehicles would be unacceptable. There is then a need to produce a small diameter neon lamp that can provide long life service in a vehicle, without failing, and not substantially changing color, or intensity. Further there is a need to produce a neon lamp electrode that is small and does not degrade appreciably over the expected life of the lamp.

Examples of the prior art are shown in U.S. patents:

U.S. patent 2,874,324 issued to G. F. Klepp et al on February 17, 1959 for Electric Gaseous Discharge Tubes shows a neon discharge device having a pressure of about 25 millimeters of mercury. By choosing the envelope size and lamp pressure, the voltage regulation of the device can optimized to offset temperature induced response variations in the device.

U.S. patent 2,812,465 issued to K. J. Germeshausen on November 5, 1957 for a Gaseous Discharge Device shows an a xenon discharge lamp using a hollow cathode. In Fig. 4 the electrode is shown as surrounded by an open ended cylinder supported at one end by a wire mesh. The can and wire mesh structure are to capture sputtered material.

U.S. patent 2,847,605 issued to A. A. Byer on August 12, 1958 for a Electrode for Fluorescent Lamps shows a fluorescent lamp with a hollow cathode electrode. The inside of the cathode is described as having a sloping emitter material leading to a greatest thickness at the rim of the spraying or dipping.

U.S. patent 3,505,553 issued to P. T. J. Piree on April 7, 1970 for a Radio Interference Free Low Pressure Mercury Vapor Lamp shows an emitter material with a boron component useful in suppressing radio interference emissions. The emitter is coated on the inside wall of a can type electrode. No particular coating method is described.

U.S. patent 3,879,830 issued to William E. Buescher on April 29, 1975 for Cathode for Electron Discharge Device Having Highly Adherent Emissive Coating of Nickel and Nickel Coated Carbonates shows an emissive coating sprayed on the electrode and baked in place. The coating material is ground to a fineness sufficient to allow liquid spraying.

U.S. patent 3,906,271 issued to Harry W. Aptt Jr. on September 16, 1975 for a Ceramic Cup Electrode for a Gas Discharge Device shows an a xenon discharge lamp using a hollow cathode. An emissive powder is pressed and sintered in the cup to anchor the material in place.

U.S. patent 3,969,279 issued to Edmond R. Kern on July 13, 1976 for Method of Treating Electron Emissive Cathodes shows a method of heat treating the emissive material on an electrode to eliminate excessive barium.

U.S. patent 4,461,970 issued to John M. Anderson on July 24, 1984 for a Shielded Hollow Cathode Electrode for Fluorescent Lamp shows several hollow cans concentricaliy positioned one inside another. The electrode coating is described as being conventional, but there is no description of how the coating is applied.

U.S. patent 4,533,852 issued to Berthold Frank et al on August 6, 1985 for a Method of Manufacturing a Thermionic Cathode and Thermionic Cathode Manufactured by Means of Said Method shows a hot cathode type electrode with a can coated internally by chemical vapor deposition.

Disclosure of the Invention

A miniature neon lamp electrode may be formed by coating an end of an electrode lead, positioning a quantity of a fluid emitter coating material on a needle end, advancing the needle end and quantity of emitter coating material into a tubular can having a rim defining a first entrance, an inside wall defining a cavity with an inside diameter less than 5.0 millimeters, and a second, entrance. The needle is then spun to deposit the emitter coating material on the inside wall. The coated inside end of the electrode lead is inserted through the second entrance and positioned in the cavity. The lead and can are then coupled, leaving the first entrance open to the cavity and the coated inside wall. The deposited emitter material is cured

on the inside wall.

Brief Description of the Drawings

FIG. 1 shows a cross sectional view of a preferred embodiment of a miniature electrode positioned in a lamp envelope, partially broken away.

FIG.s 2A - 2I show the steps of construction of the miniature electrode.

Best Mode for Carrying Out the Invention

FIG. 1 shows a cross sectional view of a preferred embodiment of a miniature electrode 10 positioned in a lamp envelope 32, partially broken away. Like reference numbers designate like or corresponding parts throughout the drawings and specification. The miniature neon lamp electrode 10 is assembled from a lead 12, a can 20, and an emitter coating 40. The electrode 10 is then sealed in a lamp envelope 32.

The lead 12 may be made out of molybdenum to have the general form of a round wire. Molybdenum is chosen to generally match the thermal expansion characteristics of the borosilicate hard glass preferred for use in the lamp envelope 32. The common quartz seal structure using a tungsten electrode, molybdenum seal foil and outer molybdenum lead wire may be used, but would be more expensive. The round lead 12 has a diameter 14, and an inside end 16. The lead diameter 14 is chosen to be small to limit heat conduction to the lamp seal, but sufficiently large to provide adequate electrical conduction for the discharge, and sufficiently large to mechanically support the electrode 10 tip structure. In the preferred embodiment, the lead 12 is butt welded to an end of an outer lead 18 having a larger diameter, and that is therefore mechanically stronger. The preferred inner lead diameter 14 is from 0.38 to 0.79 millimeters (0.015 to 0.030 inch). The lead end 16 is preferably planar, and perpendicular to the lead 12 axis. The preferred outer lead 18 has a diameter that is about 1.00 millimeter (0.04 inch).

The can 20 may be made out of any high temperature material and preferably an electrically conductive material. Tungsten, molybdenum or nickel are reasonable metals to use. The Applicants prefer nickel, or nickel alloy in the general form of a hollow tube. The can 20 has a rim 22, an overall length 24, an inside diameter 26, a thickness 28 and an outside diameter 30. The rim 22 is along the innermost limit of the electrode 10. The overall length 24 is sufficient to enclose an interior electron production region, and a means for coupling the lead 12 to the can 20. The inside diameter 26 is sufficient to admit the lead end 16 to receive an interior coating of the emitter coating 40, and to contain at least partially some of any sputtered material. The inside diameter 26 should not be so small as to limit electron production below that needed to sustain the designed for discharge. On the other hand the inside diameter 26 should not be so large as to allow the arc discharge to wander, or for material sputtered from the can enclosed portion of the lead 12 or can 20 to be immediately lost into the enclosed lamp volume. The preferred inside diameter 26 is from 0.38 millimeters (0.015 inch)(the same diameter as the smallest lead wire), to 1.5 millimeters (0.060 inch)-(the largest size can 20 that may be reasonably placed in the narrow lamp envelope 32).

The can thickness 28 is chosen so the can 20 is sufficiently strong to sustain the temperature of operation over the life of the lamp typical of vehicle use (estimated to be 200,000 starts, 10,000 hours of operation, with frequent shock and vibration). On the other hand the thickness 28 is chosen to be as small as possible, to limit the total electrode mass and thereby allow rapid heating of the electrode tip structure. The preferred thickness 28 is from 0.348 to 0.414 millimeters (0.0137 to 0.0163 inch). The outside diameter 30 then ranges from 1.466 to 1.481 millimeters (0.0577 to 0.0583 inch). The outside diameter 30 should not be so large as to close the gap between the electrode 10 and the surrounding lamp envelope 32, to less than an amount causing the lamp envelope 32 to over heat and devitrify or distort. A reasonable gap between the can 20 and the envelope 32 for the 3 millimeter inside diameter lamp has been found to be about 0.765 millimeter (0.03 inch).

The lead end 16 fits in one end the can 20, so that the inside end 16 of the lead 12 extends into the can 20, but leaving an inside offset distance 34 between the inside lead end 16 and the rim 22. There is then a full cavity 36 roughly defined by the lead end 16, the rim 22 and the inside wall of the can 20. The full cavity 36 is believed to be where most of the arc producing electrons are produced, and where most of the electrode heat occurs. The full cavity 36 should be long and narrow to provide a hollow cathode electron production response. In particular the full cavity 36 region is preferred to have an axial length to diameter ratio of greater than 1.5.

The lead 12 and can 20 are coupled together on a side toward the lamp seal. Numerous couplings methods are available. The applicants find it convenient to crimp the nickel tube forming the can 20 to the molybdenum lead 12, making two rings of four indentations each. The indentations in each ring are spread at ninety degrees around the can 20. The two rings of crimped indentations lock the

12 and can 20, and prevent the can 20 from rocking (transaxially rotating).

With the lead 12 and can 20 crimped together, a narrow cavity 38 is then formed that is roughly defined to be between the lead end 16, the inside wall of the can 20 and the junction point between the lead 12 and the can 20. The narrow cavity 38 is a further source of electrons. The lead end 16 forming the narrow cavity 38 is believed to be the hottest part of the electrode 10, and therefore the region most likely to sputter or loose material. The constrained distance between the lead end 16 and the can 20 in the narrow cavity 38 acts to capture and retain sputtered material. Material forming the walls of the narrow cavity 38 is then reasonably contained in the narrow cavity 38. The preferred axial length of the narrow cavity 46 is then equal to what would otherwise be the heated tip end of an uncovered electrode 10. The Applicants use a ratio of the lead 12 diameter to the length of the narrow cavity 46 of one third or less.

The emitter coating 40 should be a material having a low work function to enhance electron production, and thereby reduce the required operating voltage of the lamp. The emitter coating 40 should have sufficient heat and mechanical durability to last under the operating conditions. In particular, the electrode is designed to provide 40 to 70 volts RMS per centimeter of electrode separation, and at about .5 to 5.0 milliamps RMS per centimeter of electrode separation. The best operating values are thought to be about 2.2 milliamps RMS per centimeter of electrode separation. The lamp wattage may range from about 5.0 to 50.0 watts, with the longer length lamps having the greater wattages. The lamp pressure is also relevant to electrode performance. Below 10 torr, the preferred color (SAE red) is difficult to achieve, and the electrodes sputter. With increasing pressure the color improves and the electrodes last longer. Above 300 torr the ballast requirements become increasingly expensive to satisfy. The preferred pressure is from 10 to 200 torr, and more particularly in the 50 to 130 torr range. Applicants use a low work function emitter in a ceramic binder. The preferred emitter coating 40 is an alumina and zirconium getter material, known as Sylvania 8488. The emitter coating 40 is formed as a water and acetone slurry with about four (4%) weight percent alumina powder, thirty-six (36%) weight percent zirconium, and fifteen (15%) weight percent binder. The emitter coating 40 is applied to form of a thin layer coating over nearly all the exposed surfaces inside the full cavity 36 and the narrow cavity 38. The lead end 16 is coated down to where the lead 12 and the can 20 are coupled. The inside of the can 20 is also coated down to where the lead 12 and can 20 are coupled. The emitter coating 40 should be even. An uneven emitter coating 40 results in uneven electron production over time, and an uneven thermal distribution. The uneven heating, and heat conduction result in a distorted electrode 10, that wears more rapidly, and produces a poorly located arc. The emitter coating 40 should be sufficiently thick to provide a good emitter over the life of the lamp, but not so thick as to peel, flake or otherwise erode in large portions. The preferred coating weight of 1.0 milligrams is evenly, and smoothly coated inside the can.

The preferred emitter coating 40 does not extend to the rim 22 of the can 20. In the preferred embodiment, just inside the entrance to the can 20 around the rim 22, there is an uncoated band 42. The emitter coating 40 is then offset from the rim 22 by a uncoated band 42. There is reduced electron emission in the band 42. Offsetting the rim 22 from the emitter coating 40 helps limit the amount of sputtering material that may be ejected from the can 20 and deposited on the envelope 32. Material that is ejected axially out of the can 20 is likely to be evenly distributed on the envelope 32, thereby having a minimal affect. Material that is ejected at a sharp angle to the can 20 entrance, for example material that might otherwise be sputtered from the uncoated band 42, is likely to heavily deposit on the envelope 32 near the electrode 10 tip. A heavy deposit discolors the lamp, and enhances the deterioration of the envelope 32 material. The uncoated band 42 then helps increase lamp life. The uncoated band 42 preferably has an axial extension of one half the inside diameter 26 or greater. The preferred inside wall is smoothly and evenly coated with a slurry of zirconium and alumina to a sufficient depth to leave about 1.0 milligram of emitter after the slurry is dried and cured in place.

The nickel can 20 surrounds the emitter tip, and extends slightly farther, perhaps 2.0 millimeters, into the tubular envelope than does the inner most part of the electrode 10 rod, and the emitter coating 40. Emitter coating 40, or electrode 10 material that might sputter from the emitter tip tends to be contained in the extended can 20.

The manufacture of the miniature electrode 10 requires care that emitter coating 40 is not deposited on the exterior of the can 20, as electron emission sites on the exterior of the can 20 tend to draw the arc discharge to such an outside location, resulting in uneven local heating adjacent the envelope wall. The uneven heating results in deterioration of the adjacent envelope 32 material, and a shortened lamp life.

The electrode 10 is constructed by first, FIG. 2A, accurately dipping the end of the lead 12 in the emitter material 13 and curing, FIG. 2B, the coating in place with moderate heat. In the preferred procedure, the inside end 16 is heated slightly to about

37.7° C (100° F), and then dipped in a slurry of the emitter coating material. The coated inside end 16 is then dried, and cured slowly but with sufficient heat to drive off any organic or other volatile materials that would interfere with the lamp operation. Multiple dippings and curings may be used to build up a sufficiently thick emitter coating 40.

The can is then placed, and held in the jaws of a crimping device 48, FIG. 2C, 2D. A needle 44 is then dipped in the emitter material 13 so that a small quantity of the emitter material 13 is held on the needle 44 end, FIG. 2E. Applicants use a needle 44 with one or more small cross holes 46 to wick some of the emitter material 13 into the cross hole 46. A small cavity would work nearly as well. The needle 44 end is then advanced axially, into the can 20, FIG. 2F. The needle 44 is axially positioned with the cross hole(s) 46 opposite the region(s) inside the can 20 to be coated. The needle 44 is then spun, FIG. 2G, causing the emitter material 13 to spin free of the needle 44, and be deposited on the adjacent inside wall of the can 20. The emitter material 13 is deposited in a band opposite the region that was coated on the needle 44, or where the cross hole(s) 46 is(are) positioned. Selective positioning of the cross hole(s) 46 then allows selective coating of the inside wall of the can. By locating the needle 44, and cross hole 46 low enough on the needle 44, an uncoated band 42 around the rim 22 of the can 20 may be formed. Repeated spin depositions, and curings may be used to build up the emitter coating 40 to the desired thickness.

The lead 12 and can 20 are then coupled. In the preferred method, the can 20 is held in a crimping device 48, and the previously coated lead end is advanced to properly locate the inside lead end 16 in the can 20. The can 20 is then crimped to the lead 12 by a crimping tool 48, FIG 2I. Preferably, the crimping results in a coaxial alignment of the lead 12 and the can 20. The electrode is then vacuum baked to further assure extraneous materials are not introduced into the lamp. The electrode 10 is then inserted and sealed in a lamp envelope 32 by standard methods (not shown).

In a working example some of the dimensions were approximately as follows: The inner lead was made of molybdenum, and had a lead diameter 0.5 millimeters (0.02 inch). The lead end was coated for an axial length of 2.0 millimeters (0.078 inch) to a depth sufficient to leave about 1.0 milligram of cured emitter in place. The outer lead was made of nickel plated steel wire, and had a lead diameter 1.0 millimeter (0.40 inch). The inner and outer leads were butt welded together and had a combined length of 50.54 millimeters (2.0 inch). The can was made of nickel, and had a length of 6.00 millimeters (0.236 inch), an inside diameter of 1.09 millimeters (0.043 inch), an outside diameter of 1.473 millimeters (0.058 inch). The can was coated inside in a band from between 0.38 millimeters (0.015 inch) to 4.31 millimeters (0.170 inch) from the rim of the can. An uncoated band of 0.38 millimeters (0.015 inch) was left around the inside of the rim. About 1.0 milligram of dry emitter material was deposited on the inside of the can. This provided an area concentration of about 0.075 grams per square millimeter. Concentrations of from 0.050 to 0.100 grams per square millimeter are felt to be functional. The coated lead and coated can were then crimped together. The crimping coaxially coupled the lead and can. The inside end of the lead was internally offset from the rim of the can by 2.0 millimeters (0.078 inch). An offset of the lead end to the rim equal to or greater than the inside can diameter is preferred. About 2.0 millimeters (0.078 inch) of the coated lead were exposed in the depth of the can before the crimp joined the can to the lead.

While there have been shown and described what are at present considered to be the preferred embodiments of the invention, it will be apparent to those skilled in the art that various changes and modifications can be made herein without departing from the scope of the invention defined by the appended claims.

Claims

1. A miniature neon lamp electrode comprising:
   a) a lead having a diameter and an inside end,
   b) a tubular can having a rim defining an entrance, and an inside wall defining an inside diameter less than 5.0 millimeters, the can being coupled to the lead end to enclose the lead end and offset the lead end from the rim, and
   c) an emitter coating evenly formed on the inside wall of the can.

2. The miniature electrode in claim 1, wherein the enclosed lead end is additionally coated with the emitter material.

3. The miniature electrode in claim 1, wherein an interior portion of the lead is narrower than an exterior portion of the lead.

4. The miniature electrode in claim 1, wherein the can has an inside diameter of less than 2 millimeters.

5. The miniature electrode in claim 1, wherein the can has a wall thickness less than 0.5 millimeters.

6. The miniature electrode in claim 1, wherein the can has an overall length less than 10 millimeters.

7. The miniature electrode in claim 1, wherein the inside length is about twice the length of the enclosed portion of the lead.

8. The miniature electrode in claim 1, wherein the inside end of the lead is offset from the rim of the can by at least the inside diameter of the can.

9. The miniature electrode in claim 1, wherein the emitter coating includes a getter.

10. The miniature electrode in claim 1, wherein the inside wall around the rim of the can is not coated with an emitter, and other portions inside the can are coated with an emitter.

11. The miniature electrode in claim 1, wherein the emitter coating has an area concentration of from 0.05 to 0.1 grams per square millimeter.

12. The miniature electrode in claim 1, wherein the emitter coating has an area concentration of about 0.075 grams per square millimeter.

13. A method of making a miniature neon lamp electrode comprising:
a) positioning a quantity of a fluid emitter coating on a needle end,
b) advancing the needle end and quantity of emitter coating material into a tubular can having a rim defining a first entrance, an inside wall defining a cavity with an inside diameter less than 5.0 millimeters, and a second entrance,
c) spinning the needle to deposit the emitter coating material on the inside wall,
d) inserting an inside end of an electrode lead through the second entrance,
e) coupling the lead to the can leaving the first entrance open to the cavity and the coated inside wall, and
f) curing the deposited emitter material on the inside wall.

14. The method in claim 12, further including the steps of coating an end of the electrode lead, and positioning the coated lead end of the lead in the cavity.

15. The method in claim 12, wherein the needle includes at least one cavity to retain a quantity of emitter material.

16. The method in claim 12, wherein the can is crimped to the lead to coaxially align the lead and the can.

17. The method in claim 12, wherein the emitter is coated on the inside wall of the can leaving a region free of emitter around the inside surface of the first entrance.

18. The method in claim 12, wherein the can is symmetrically crimped to coaxially position the can with respect to the lead.

19. The method in claim 12, wherein the lead is advanced into the can leaving an offset from the lead end to the first entrance at least equal to the inside diameter of the can.

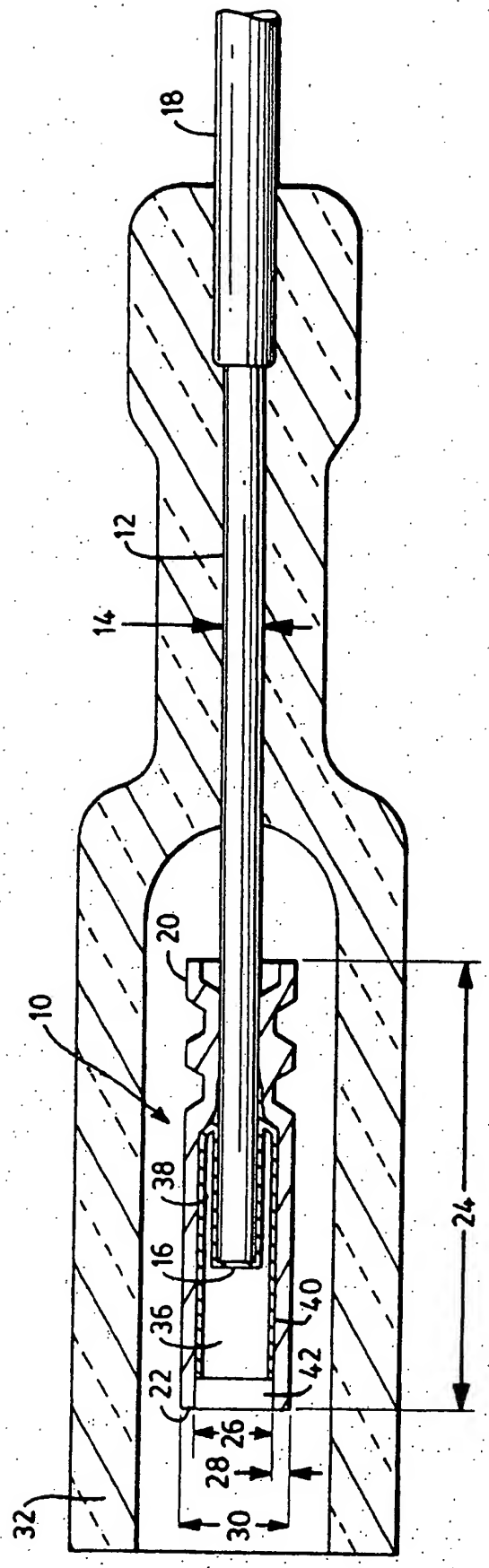

FIG. 1

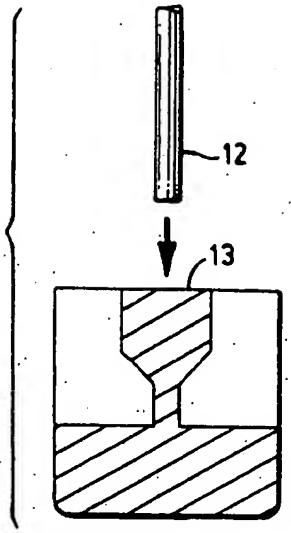

FIG. 2A

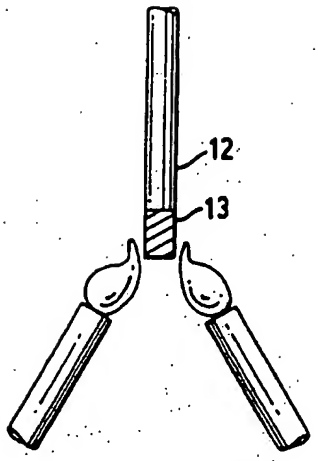

FIG. 2B

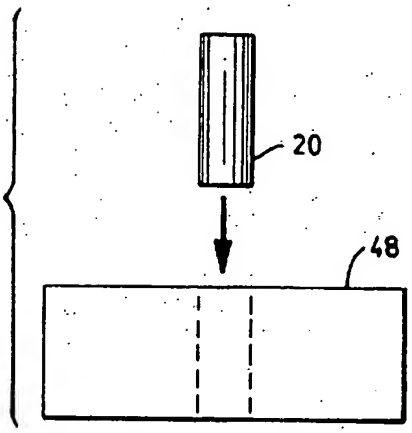

FIG. 2C

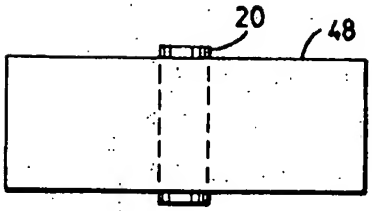

FIG. 2D

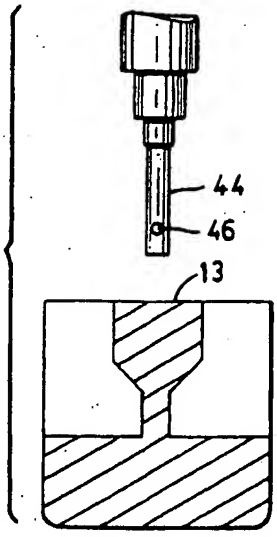

FIG. 2E

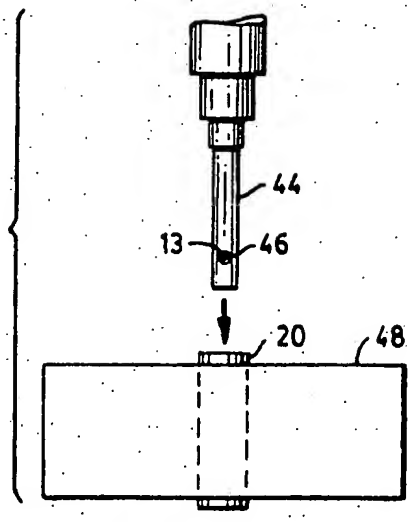

FIG. 2F

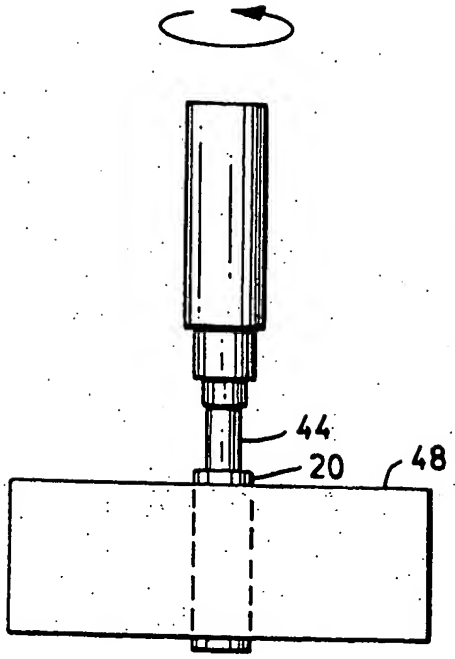

FIG. 2G

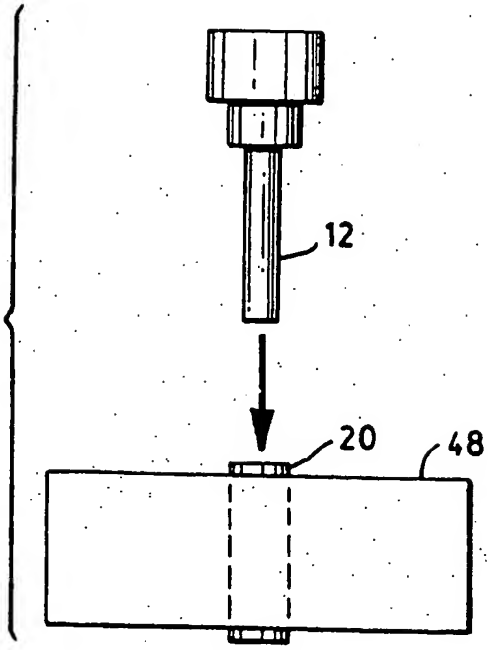

FIG. 2H

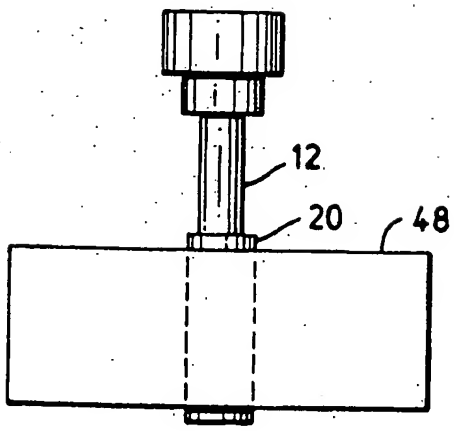

FIG. 2I